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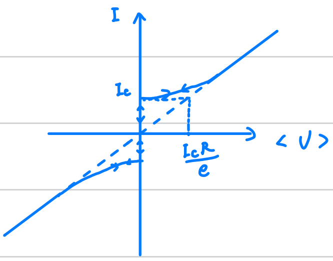
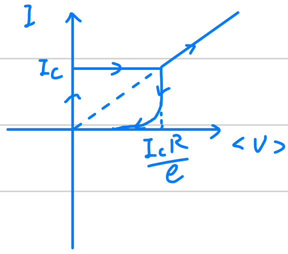
1. 对于过阻尼情况 ($\beta_c \ll 1$)

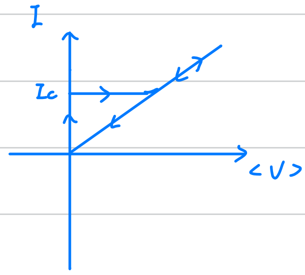


由于阻尼的作用没有回滞现象。

对于欠阻尼情况 ($\beta_c \gg 1$)

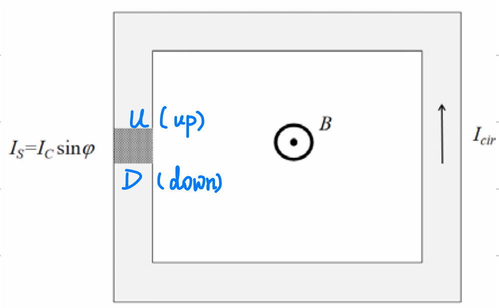


无并联电阻时回滞曲线类似矩形



有并联电阻时有回滞，且回滞曲线类似三角形.

2.



(i) 利用 G-L II $\nabla\theta = \frac{2\pi}{\Phi_0}(\Lambda\vec{J}_s + \vec{A})$ 其中 $\Lambda = \frac{m}{n_s q^2}$.

则有 $\varphi + \oint \nabla\theta\cdot d\vec{l} = \varphi + \frac{2\pi}{\Phi_0}\oint(\Lambda\vec{J}_s+\vec{A})\cdot d\vec{l} = 2n\pi$

即 $\varphi = -\frac{2\pi}{\Phi_0}\Phi + 2n\pi$. 其中 $\Phi = \oint(\Lambda\vec{J}_s+\vec{A})\cdot d\vec{l}$ 为环路总磁通.

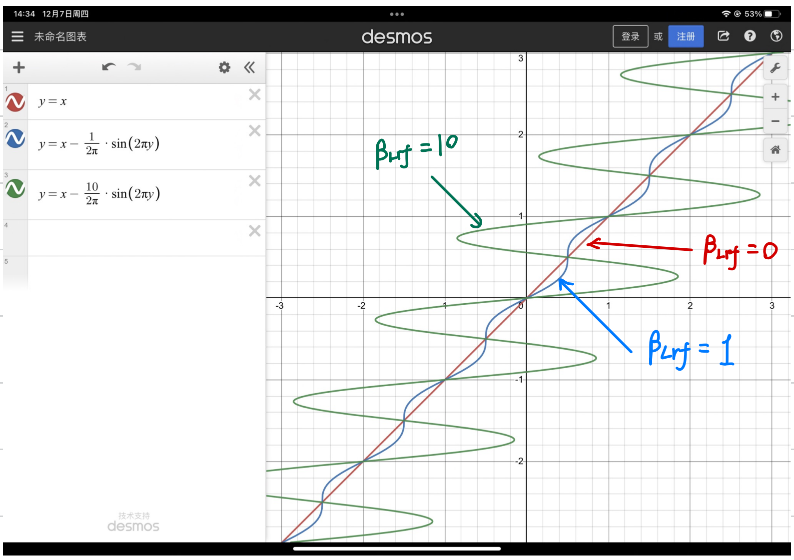
则结上的超导电流为

$$I_s = I_c\sin\varphi = I_c\sin\left(-\frac{2\pi\Phi}{\Phi_0}+2n\pi\right) = -I_c\sin\left(\frac{2\pi\Phi}{\Phi_0}\right)$$

(ii) 由题意可知, $\Phi = \Phi_{ext} + LI_{cir} = \Phi_{ext} - LI_c\sin\left(\frac{2\pi\Phi}{\Phi_0}\right) = \Phi_{ext} - \frac{\Phi_0}{2\pi}\beta_{Lrf}\sin\left(\frac{2\pi\Phi}{\Phi_0}\right)$

两侧同时除以 Φ_0 得: $\frac{\Phi}{\Phi_0} = \frac{\Phi_{ext}}{\Phi_0} - \frac{\beta_{Lrf}}{2\pi}\sin\left(\frac{2\pi\Phi}{\Phi_0}\right)$

$\beta_{Lrf} = 0, 1, 10$ 三种情况下 $\frac{\Phi}{\Phi_0}$ 随 $\frac{\Phi_{ext}}{\Phi_0}$ 变化如下图.



3. 当结区磁通取典型值 $\Phi = \Phi_0 = \frac{h}{2e}$ 时

$$E_B = \frac{1}{2\mu_0}\frac{\Phi_0^2 W}{L t_B}\ ;\qquad E_J = \frac{\Phi_0 I_c}{2\pi}$$

则 $E_B \gg E_J$ 可得: $\frac{1}{2\mu_0}\frac{\Phi_0^2 W}{L t_B} \gg \frac{\Phi_0 I_c}{2\pi}$ 其中电流 $I_c = J_c\cdot LW$, J_c为电流密度.

则不等式可化为: $\frac{2\pi\Phi_0 e}{L^2\hbar}\left(\frac{\hbar}{2\mu_0 e t_B J_c}\right) \gg 1$ 代入 $\lambda_J = \sqrt{\frac{\hbar}{2\mu_0 e t_B J_c}}$ 以及 $\Phi_0 = \frac{h}{2e}$.

得 $\lambda_J^2 \gg \frac{1}{2\pi^2}L^2$ 两侧开跟号有 $\lambda_J \gg \frac{1}{\sqrt{2}\pi}L$ 即 $E_B \gg E_J$ 满足约瑟夫森结是小结的条件。